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A Systematic Comparison between the Places of Stars given in the Cape Catalogue for 1880 *and the Radcliffe Catalogue for* 1890.

By E. J. Stone, M.A., F.R.S., Radcliffe Observer.

My wish is that the Radcliffe Catalogue for 1890 should be regarded as a continuation and completion of the general survey of the southern sky, which I commenced at the Cape in 1870. The agreement or disagreement of the results of these Catalogues is therefore, from my point of view, one of primary importance.

In collecting the materials for the Cape Catalogue, 1880, the chief object in view was to fix the positions of well-distributed zero points from the South Pole, N.P.D. 180°, to less than N.P.D. 115°, with all the accuracy attainable within the limits of the probable error of the mean of at least three observations of each element. In the collection of the materials included in the Radcliffe Catalogue the same plan has been followed for the stars from N.P.D. 115° to the Equator. But it was my earnest wish to render the results *as independent as possible* ; and to trust to the agreement or disagreement of the results which overlap as a test of the accuracy attained. I, therefore, purposely made the Oxford observations well overlap those at the Cape to afford materials for this comparison ; and I need hardly say that I have looked forward to the result with some natural anxiety.

The comparison has now been systematically and regularly carried out. The number of observations compared has been very considerable ; and the work of comparison has involved much arithmetical labour ; but the results can be exhibited in the form of tables, without taking up any great amount of space.

I have also added a comparison between the Radcliffe results and those of the Greenwich Ten-year Catalogue for 1880. The systematic differences are nearly the same as those between the Radcliffe Catalogue, 1890, and the Greenwich Five-year Catalogue of 258 Fundamental Stars for 1890, given in the *Monthly Notices* for November, 1894 ; but the comparisons given in the present paper include a much greater number of stars.

The positions in the Radcliffe Catalogue, 1890, for stars of much greater N.P.D. than 115° are not, of course, of much value, either in R.A. or N.P.D., except for discussion of questions of refraction ; and similar remarks apply to those of the Cape Catalogue for N.P.D. much less than 45°.

An examination of the differences in R.A. and N.P.D. between the Radcliffe and Cape Catalogues shows the existence of small but systematic differences both in R.A. and N.P.D. I am not, at present, able to give any perfectly satisfactory explanation of the cause of the change of these differences in R.A. with the N.P.D., which are certainly rather larger than I expected, and which possibly may be chiefly due to the Oxford observations,

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although the R.A.'s of the Melbourne Catalogue, 1880, certainly show a similar law of discordance from those of the Greenwich Catalogue, 1880 (see Dr. Downing's Table V. p. 310, *Monthly Notices*, vol. li.). But these differences are at all events as small as those between the determinations of epoch corrections required by the different systems of fundamental stars at present employed; and the mean differences between the two Catalogues from the equator to N.P.D. 115° are so small that the results may be combined without leading to errors of any practical importance. The differences between the N.P.D. of the two Catalogues are so small that the application of a correction of + 0″·20 to the Radcliffe N.P.D. and − 0″·20 to the Cape N.P.D. would remove the discrepancy; and such errors are certainly within the limits of those which may arise from defects of the refraction tables in use.

The Greenwich observations differ more from the Radcliffe observations than those made at the Cape, and these differences agree with the results found from a comparison between the Greenwich, 1890, and the Radcliffe, 1890; but I have nothing, at present, to add on this point to my remarks in the *Monthly Notices* for November. With regard to the general accuracy of the Cape and Radcliffe results, I would appeal to the comparison between the Cape, 1880, and the Argentine General Catalogue for 1875 given by Dr. Downing in the *Monthly Notices* for June, 1887. As a matter of fact the N.P.D.'s of the Argentine Catalogue agree almost identically, in mean results, with the Radcliffe, 1890.

As a further check I give the comparisons between the results of the Cape Catalogue, 1885, lately published by Dr. Gill; but I have taken these results *directly from the General Catalogue, as found from the Cape work*, without applying certain corrections which Dr. Gill has shown would make his results agree rather more closely with those of the Greenwich Catalogues. This course is necessary if the agreement between the Cape and Greenwich results is to be appealed to as a proof of the accuracy of the positions of the stars given in these Catalogues.

The co-latitude of the Cape found by Dr. Gill from the circumpolar stars, and adopted in the formation of his Catalogue, is

123° 56′ 3″·35;

whilst that adopted in the Cape Catalogue, 1880, is

123° 56′ 3″·41;

and these results are, therefore, in close agreement.

The N.P.D.'s of the 1880 and 1885 Catalogues should therefore agree for stars at N.P.D. 124°. This is found to be the case; and the differences between the results should be confined within smaller limits than 0″·25 for all stars between N.P.D. 70°

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and 124°, if they are unaffected by any other systematic errors than the effects on the refractions of a difference of 1°·6 F. due to an alteration of the thermometer exposures. But an examination of the differences of the division corrections applied 1870–1879 and 1880–1885, although small, will show that they are of the order of magnitude which is here under consideration. The results included in the Cape Catalogue, 1885, are also certainly not free from suspicion of systematic errors of sensible amount when the R – D discordance varies between + 1″ and – 1″ (see Table I. p. xvii. of the Cape, 1885, Catalogue); and although the R – D discordance was certainly confined within much smaller limits at the Cape, during the years 1874–1879, I am not prepared to assert that these observations may not have been affected by some small systematic errors due to the same causes which have affected the observations 1880–1885, and which I believe to be chiefly instrumental.

It should be mentioned that the fundamental epoch of the Cape Catalogue, 1880, is that of the Greenwich standard list; whilst Dr. Gill has adopted for the Cape Catalogue, 1885, the fundamental epoch of Dr. Auwers' "Fundamental-Catalog für die Zonen-Beobachtungen am nördlichen Himmel," and this is the chief cause of the small and nearly constant differences in R.A.

If the corrections, which Dr. Gill has deduced from a discussion of the Pulkowa and Greenwich observations, are applied to the results of the Cape Catalogue, 1885, the N.P.D.'s agree rather more closely with the Cape Catalogue, 1880, and less closely with the Radcliffe, 1890, than before; but the differences are in both cases *exceedingly small*, as will be seen on reference to the Tables given in this paper (see Tables I. and III.).

With regard to the non-application of any corrections for R – D discordance to the Radcliffe observations, the mean differences for R – D with the zenith-points found from the Nadir observations given in the results 1881–1887, after corrections for flexure have been, as they should be, applied, is for North stars —0″·235 with a weight 1518, and for South stars – 0″·104 with a weight 2084, and these differences would only indicate an error in mean Nadir correction of

$$+0''{\cdot}080\,;$$

a quantity, whose effects are included in the co-latitude investigation, and which I consider too small and uncertain in its determination to render it necessary, for practical purposes, to discuss whether it is due to error of flexure correction, outstanding errors of division, or causes affecting solely the reflexion observations connected with atmospheric conditions in the observing room; or rather to their combined effects. My experience does not give me much confidence in the freedom of absolute places from systematic errors much less than ±0″·25; and, although I have tried to keep the errors as small as possible,

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I certainly do not claim that either the results of the Cape Catalogue, 1880, or the Radcliffe Catalogue for 1890 are free from possible systematic errors within such limits. But the agreement between the Cape, 1880, results and those of the Radcliffe, 1890, is an unforced one; the systematic discordances are certainly confined within narrow limits: and the results of the two Catalogues combined afford positions of stars well distributed over the whole Southern hemisphere, which are not, so far as I can test them, affected with any serious systematic errors.

TABLE I.

Mean Results of Comparisons between Radcliffe, 1890. *Stone*, 1880, *and Greenwich*, 1880.

Group.	Mean N.P.D. of Group, Stone.	Differences in R.A. × sin N.P.D.				Differences in N.P.D.			
		Radcliffe minus Stone.	Wt.	Radcliffe minus Greenwich.	Wt.	Radcliffe minus Stone.	Wt.	Radcliffe minus Greenwich.	Wt.
°	° ′	s		s		″		″	
0–5	...	...	...	+0·014	636	...	...	−0·13	706
5–10	...	...	...	+0·024	17	...	...	+0·08	36
10–15	...	...	..	−0·017	54	...	...	+0·11	88
15 20	...	...	...	−0·014	71	...	...	−0·23	157
20–25	...	...	...	−0·017	64	...	...	−0·40	160
25 30	...	...	...	−0 002	62	...	...	−0·68	194
30–38¼	...	...	...	−0·005	55	...	...	−0·57	64
38¼–45	42 0	+0·015	4	+0·001	67	−0·72	10	−0·64	69
45–50	46 0	+0·050	5	+0·027	44	−0·27	7	−0 29	8
50–55	52 0	+0·045	11	+0·014	74	−0·83	13	−0·55	106
55–60	57 30	+0·042	22	+0·031	69	−0·10	6	−0·51	87
60–65	62 0	+0 056	118	+0 040	229	−0·33	24	−0·88	205
65–70	68 0	+0 041	130	+0·036	296	−0·60	36	−0·86	222
70–75	72 30	+0·057	151	+0·043	346	−0·39	29	−0·78	251
75–80	77 30	+0·037	233	+0·038	405	−0·48	45	−1·17	213
80–85	82 30	+0·034	293	+0·034	482	−0·36	69	−1·10	196
85–90	87 30	+0·036	181	+0·028	352	−0·53	48	−0·73	169
90–95	92 30	+0·017	397	+0 014	600	−0·49	193	−0·68	427
95–100	97 30	−0·004	352	−0·017	617	−0·63	179	−0·91	438
100–105	102 30	−0·021	259	−0·040	495	−0·38	174	−0·84	393
105–110	107 30	−0·024	277	−0·051	606	−0·47	123	−0·93	484
110–115	112 30	−0·053	642	−0·078	368	−0·36	550	−0·98	327
115–120	117 30	−0·064	303	−0 091	195	−0·04	254	−0·96	160
120–125½	122 30	−0·133	145	−0·158	45	−0 84	155	−0·79	47

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TAB

Differences between the Radcliffe Catalogue, 1890 ; *the Cape Catalogu*

Differences

N.P.D. of Group.	0^h to 6^h.				6^h to 12^h.				12^h
	Radcliffe minus Cape, 1880.	Weight.	Radcliffe minus Greenwich, 1880.	Weight.	Radcliffe minus Cape, 1880.	Weight.	Radcliffe minus Greenwich, 1880.	Weight.	Radcliffe minus Cape, 1880.
° °	s		s		s		s		s
45 to 50	+0·036	1	+0·024	19	...	...	+0·006	8	...
50 „ 55	−0·063	1	+0·025	32	...	...	...	...	+0·135
55 „ 60	+0·025	3	+0·047	9	−0·025	5	+0·010	20	+0·061
60 „ 65	+0·034	20	+0·029	44	+0·050	31	+0·064	44	+0·057
65 „ 70	+0·067	37	+0·042	118	+0·028	87	+0·032	138	...
70 „ 75	+0·042	44	+0·043	103	+0·052	58	+0·039	107	+0·076
75 „ 80	+0·035	30	+0·047	70	+0·030	78	+0·039	124	+0·032
80 „ 85	+0·023	75	+0·022	155	+0·029	94	+0·029	148	+0·050
85 „ 90	+0·035	53	+0·025	84	+0·024	31	+0·028	79	+0·032
90 „ 95	+0·005	136	+0·019	158	−0·003	76	+0·007	65	+0·035
95 „ 100	−0·005	161	−0·010	197	−0·008	78	−0·019	73	−0·018
100 „ 105	−0·036	73	−0·061	89	−0·025	63	−0·036	95	−0·002
105 , 110	−0·010	63	−0·053	82	−0·035	70	−0·053	98	−0·028
110 „ 115	−0·055	173	−0·076	74	−0·066	132	−0·075	78	−0·057
115 „ 120	−0·004	40	−0·012	6	−0·104	76	−0·114	38	−0·082
Means 45 „ 120	−0·003		+0·005		−0·010		+0·003		−0·009
„ 90 „ 115	−0·021		−0·024		−0·031		−0·038		−0·022

Differenc

N.P.D. of Group.									
° °	″		″		″		″		″
45 to 50	+1·03	4	+0·04	25	...	...	−0·72	8	...
50 „ 55	+1·09	2	−0·32	19	...	...	...	...	−1·03
55 „ 60	−0·03	2	−0·11	10	+0·05	2	−0·76	26	+0·27
60 „ 65	−0·47	6	−0·71	43	−0·02	8	−0·92	27	−0·87
65 „ 70	−0·50	14	−0·82	84	−0·81	19	−0·88	111	...
70 „ 75	−0·39	10	−0·85	66	−0·45	9	−0·97	61	−0·34
75 „ 80	−0·12	10	−0·96	40	−0·46	15	−1·27	76	−0·57
80 „ 85	−0·38	26	−0·95	62	−0·13	16	−1·04	68	−0·68
85 „ 90	−0·38	10	−0·58	31	−0·47	12	−0·75	49	−0·55
90 „ 95	−0·46	87	−0·66	116	−0·50	54	−0·54	59	−0·66
95 „ 100	−0·52	83	−0·85	119	−0·77	50	−0·71	64	−0·97
100 „ 105	−0·17	51	−0·74	79	−0·41	49	−0·90	82	−0·82
105 „ 110	−0·13	25	−0·88	61	−0·63	43	−0·65	86	−0·75
110 „ 115	−0·45	163	−1·10	68	−0·36	111	−0·91	65	−0·23
115 „ 120	−0·06	40	−1·45	6	+0·16	68	−0·57	39	−0·36
Means 45 „ 120	−0·35		−0·78		−0·39		−0·85		−0·44
„ 90 „ 115	−0·41		−0·82		−0·49		−0·75		−0·43

II.

1880; *and the Greenwich*, 1880; *for Six-hour Groups.*

R.A. sin N.P.D.

18^h.		18^h to 24^h.				0^h to 24^h.				
Radcliffe minus Greenwich, 1880.	Weight.	Radcliffe minus Cape, 1880.	Weight.	Radcliffe minus Greenwich 1880.	Weight.	Radcliffe minus Cape. 1880.	Weight.	Radcliffe minus Greenwich, 1880.	Weight.	Mean N.P.D. in Cape, 1880.
s		s		s		s		s		° ′
+0·065	2	+0·054	4	+0·036	15	+0·050	5	+0·027	44	46·0
+0·005	19	+0·048	9	+0·009	23	+0·045	11	+0·014	74	52·0
+0·046	30	+0·093	4	+0·013	10	+0·042	22	+0·031	69	57·30
+0·035	96	+0·081	21	+0·037	45	+0·056	118	+0·040	229	62·0
+0·002	5	+0·067	6	+0·035	35	+0·041	130	+0·036	296	68·0
+0·045	123	+0·086	2	+0·052	13	+0·057	151	+0·043	346	72·30
+0·034	73	+0·047	86	+0·035	138	−0·037	233	+0·038	405	77·30
+0·064	38	+0·042	91	+0·045	141	−0·034	293	+0·034	482	82·30
+0·036	110	+0·046	48	+0·021	79	−0·036	181	+0·028	352	87·30
+0·013	179	+0·034	84	+0·013	198	−0·017	397	+0·014	600	92·30
−0·023	132	+0·008	73	−0·018	215	−0·004	352	−0·017	617	97·30
−0·033	144	−0·017	75	−0·037	167	−0·021	259	−0·040	495	102·30
−0·053	197	−0·019	63	−0·046	229	−0·024	277	−0·051	606	107·30
−0·086	130	−0·034	152	−0·071	86	−0·053	642	−0·078	368	112·30
−0·099	62	−0·038	93	−0·082	89	−0·064	303	−0·091	195	117·30
−0·006		+0·007		−0·010		−0·004		−0·002		
−0·035		−0·010		−0·027		−0·021		−0·030		

in N.P.D.

″		″		″		″		″		° ′
−1·15	3	−1·99	3	−0·39	22	−0·27	7	−0·29	58	46·0
−0·79	39	−1·43	4	−0·43	48	−0·83	13	−0·55	106	52·0
−0·47	35	−0·92	1	−0·46	16	−0·10	6	−0·51	87	57·30
−1·03	83	−0·12	5	−0·77	52	−0·33	24	−0·88	205	62·0
−0·60	6	+0·27	3	−1·03	21	−0·60	36	−0·86	222	68·0
−0·67	117	−0·36	1	−0·27	7	−0·39	29	−0·78	251	72·30
−1·07	38	−0·72	14	−1·27	59	−0·48	45	−1·17	213	77·30
−1·64	17	−0·42	22	−1·19	49	−0·36	69	−1·10	196	82·30
−0·74	47	−0·64	15	−0·81	42	−0·53	48	−0·73	169	87·30
−0·70	137	−0·45	30	−0·76	115	−0·49	193	−0·68	427	92·30
−0·87	112	−0·55	31	−1·09	143	−0·63	179	−0·91	438	97·30
−0·79	95	−0·42	60	−0·90	137	−0·38	174	−0·84	393	102·30
−0·91	168	−0·31	31	−1·10	169	−0·47	123	−0·93	484	107·30
−0·85	113	−0·39	143	−1·11	81	−0·36	550	−0·98	327	112·30
−1·13	61	+0·20	62	−1·01	54	−0·04	254	−0·96	160	117·30
−0·85		−0·35		−0·95		−0·38		−0·86		
−0·83		−0·41		−1·00		−0·44		−0·87		

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TABLE III.

Comparisons between the Cape Catalogues, 1880 (*Stone*), *and* 1885 (*Gill*).

Group.	Stone minus Gill in R.A. $\delta\alpha$. sin Δ.	Weight.	Stone minus Gill in N.P.D. $\delta\Delta$.	Weight.
N.P.D.				
°	s		″	
70–75	−0·031	87	−0·13	23
75–80	−0·024	183	−0·08	47
80–85	−0·025	313	+0·04	94
85–90	−0·036	186	+0·23	56
90–95	−0·032	330	+0·29	142
95–100	−0·033	311	+0·27	136
100–105	−0·024	176	+0·28	111
105–110	−0·014	218	+0·35	104
110–115	−0·041	210	+0·29	123
115–120	−0·035	178	0·03	132

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On the mean places of Eight Southern Close Polar Stars.

By E. J. Stone, M.A., F.R.S., Radcliffe Observer.

In 1874 February I published and circulated the mean places of eight Southern close Polar Stars for the years 1860–1900. These places were deduced almost exclusively from observations made at the Cape Observatory, 1829–1873. The observations were brought up from one epoch to another, accurately by the trigonometrical method, with Peters' value of the precession constant; and the proper motions given are merely the small outstanding corrections found from a discussion of the residual errors, on the assumption that the places required corrections of the form

$$\text{constant} + \text{constant}\ (t - 1860).$$

The publication of a Cape Catalogue of 1,713 stars by Dr. Gill has led me to compare the computed places with the following Catalogues:—Cape, 1860; Melbourne, 1870; Cape, 1880; Cape, 1885; and the Appendix to the Cape, 1885, which gives the results of the circumpolar observations, 1881–1888 for the epoch 1885.

The agreement of the computed places with the catalogued places appears to me remarkable for such close circumpolar stars; in fact, the differences between the Right Ascensions given in the General Catalogue, 1885, and the Appendix are as great as the discordances between the computed and catalogued places themselves.

But my chief object in writing this Note has been to call attention to the smallness of the "proper motions in R.A." The fact that these residual motions are small for stars whose places were not employed in determining the precession constant, whilst the Right Ascensions of these eight stars change by such quantities as

$$-1^{m}\ 33^{s};\ -28^{m}\ 30^{s};\ +10^{m}\ 20^{s};\ +16^{m}\ 11^{s}$$
$$+1^{h}\ 21^{m}\ 10^{s};\ +1^{h}\ 25^{m}\ 55^{s};\ +10^{m}\ 36^{s};\ \text{and}\ +10^{m}\ 1^{s}$$

in 45 years, appears to afford independent evidence of the accuracy of Peters' value of the precession constant.